AIN SHAMS UNIVERSITY
FACULITY OF ENGINEERING
CAIRO - EGYPT

Field Theory Analysis of Microwave Dielectric Resonator Antennas

A Thesis

Submitted in Partial Fulfillment of the Requirement

For the Degree of Master of Science in Electrical Engineering

(Electronics and Communication Department)

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Statement

This thesis is submitted in partial fulfillment of the requirement of the degree of Master of Science in the Electronics and Communications Electrical Engineering Department, Ain Shams University.

The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or qualification at any other university or institute.

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Abstract

Dielectric resonator antennas (DRAs) have attracted broad attentions in various applications due to their attractive features in terms of high radiation efficiency, light weight, small size, low profile and different methods of excitation that can be used. The main limitation of the DRAs is the narrow bandwidth, so the initial motivation behind this thesis is to enhance the bandwidth of the rectangular DRA through the combination of the rectangular dielectric resonator with other resonators such as a slot and each radiator is designed to radiate at two separated bands. If the two bands are close to each other, a hybrid resonator can offer broadband operation. Analytical treatment based on the existing theory of a dielectric waveguide model DWM of the rectangular DRA concurrently with the method of separation of variables were used to predict resonant frequency and quality factor for the lowest order mode of the rectangular DRA. Field theory analysis of the feeding scheme using transmission line model of aperture coupling was also used. A Matlab program based on the finite difference time domain FDTD as a numerical technique for predicting the resonant frequency of the rectangular dielectric resonator was built. In order to check the correctness of the program it was applied on perfect electric conductor air filled rectangular cavity. Mathematical representation of Maxwell's equations, accuracy and stability, sources that can be used, conversion from time domain to frequency domain, absorbing boundary condition and near to far field transformation were also discussed. A design procedure and the prediction of the radiation pattern using the ready-made software package HFSS were implemented. The resonant frequency and impedance bandwidth of the offset aperture coupling rectangular DRA were computed. A primary focus of the experimental work was to choose the DRA parameters (geometric dimensions, dielectric constant ε_r and excitation method) carefully to make the DRA suitable for a wide S-band application (2 - 4) GHz. The designed DRA and an aperture coupled microstrip patch antenna were fabricated using thin film technology and photolithographic technique. Good agreement was found among analytical, numerical and experimental results. The DRA gave wider bandwidth than the conventional microstrip antenna using the same method of excitation.

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